Dragster is an assimilative tool designed to provide drag specification for the majority of resident space objects. Dragster can ingest more data than previous assimilative models because it assimilates data from a variety of sources, including satellite TLEs, atmospheric models, and remote sensing data. Dragster is capable of taking advantage of the increasing quantity of orbital data available from CubeSats and SmallSats.

**ABSTRACT:**

1. Satellite drag variability caused by the dynamics of the upper atmosphere is a major cause of orbit specification and prediction errors in Low Earth Orbit. The problem is particularly severe during geomagnetic storms. These storms can severely degrade the accuracy of conjunction analysis between debris and spacecraft with LEO perigees and all other resident space objects.

2. We describe an assimilative upper atmosphere model (Dragster) capable of taking advantage of the increasing quantity of orbital data-of-opportunity presented by SmallSats.

3. We show that many CubeSats and SmallSats can be used to calibrate the state of the atmosphere.

4. This calibrated data can be used to improve global atmospheric modeling and orbital predictions for both space debris and active satellites.

Dragster assimilates orbital data from a cross-calibrated database of resident space objects. Examples of a few are illustrated on the left.

The plot below (a) shows density errors relative to the JB08 model for all validation satellites as a function of perigee altitude.

- One year Dragster run using NRLMSIS-00 as the background atmospheric model (9/2015 to 1/2016 results shown below)
- Public TLE’s assimilated into Dragster
- Special perturbations orbit solutions from high-task tracking assimilated into HASDM. HASDM available for 4 satellites.
- Dragster state vector includes both solar and geomagnetic forcing
- Test demonstrates reduction in errors over background model
- Preliminary test results demonstrate that Dragster can outperform or match JB08 and HASDM

**Results**

- Improved satellite orbit nowcast and 72h forecast
- Improvements over HASDM and JB08
- Up to three-fold improvement during storms and solar minimum
- Densities, winds and composition outputs
- Covers altitudes from 30 km to 1500 km
- Improved performance during geomagnetic storms

**Super-Ensemble Approach**

- Output information feeds into existing orbit prediction and determination tools

**Architecture**

- High Latitude Trojans
- Solar Power
- Super-Ensemble of Full-Physics Models
- Ensemble Kalman Filter
- Use of TLEs/DR data
- Output information feeds into existing orbit prediction and determination tools

**Using DANDE as a validation object for assimilation results for 2015**

Preliminary test runs are performed using publically available orbits (two line elements) and NRLMSISE-00 as the background model.

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**Dragster software includes detailed aerodynamic models.** This allows assimilation of data from objects whose A/m ratios are not constant but vary in a predictable way. This means Dragster can ingest more data than previous atmospheric-calibration tools.

**Dragster consists of several ensemble model backgrounds** (CTIpe, TIME-GCM, TIE-GCM, MSIS, JB08). Models are in turn driven by ensemble assimilation. Much like hurricane predictions, Dragster will propagate each model forward to predict the most probable trajectory of the thermospheric state and its uncertainty. Unlike tropospheric weather, the thermosphere is strongly driven by external inputs. Therefore, forecast of the input will play an important role in reducing satellite drag errors. ASTRa is teaming with SET to include their state-of-the-art forcing and index forecasts.